RAP ensemble and GSI hybrid with RAP regional ensemble

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1. Utility to downscale the GFS ensemble to generate the RAP ensemble initial conditions

A utility was developed to generate ARW ensemble initial field using perturbations from GFS ensemble. This utility is based on the available functions in the regional GSI-hybrid, which uses the GFS ensemble to create the ensemble-based background error covariance. The functionalities in this utility include:

1. For each GFS ensemble member, it reads in the spectral coefficients and transforms the GFS ensemble from spectral coefficients to Gaussian grid field.
2. Performs horizontal interpolation to get the GFS ensemble forecast over the regional ensemble grid (A grid).
3. Generates ensemble perturbations in the horizontal regional ensemble grid.
4. Does vertical interpolation of the ensemble perturbations to generate the ensemble perturbations over the three-dimensional regional ensemble grid.
5. Converts the perturbations from A grid to C grid, and adds the perturbations to a ARW initial file to generate ensemble initial files.

2. Completed 3-Day RAP ensembles

This utility was used to generate 6-hourly 80 RAP ensemble initial condition fields based on the GFS ensembles from 18Z, August 08 to 00Z, August 12, 2014. Every 6-h in those three days, a set of 80-member RAP ensemble member forecasts was conducted for 12-h forecast with hourly output files.

For the 12-h 80-member RAP ensemble forecast, 1600 cores were used with 7 hour wall-clock time, and near 3T of disk space was used to save the results.

We will use RAP ensemble forecast initialized at 18Z, August 08, 2014 as example to check the characteristic of RAP ensemble. Vertical profiles of horizontally averaged ensemble spread for T, Q, and U at every 3-h for the 12-h ensemble forecast are plotted in Figure 1. For T and Q, forecast spread is clearly larger than initial fields, especially for up level T field. However, the spread for T and Q at near surface level is reduced slightly during the forecast. This may indicate we need to figure out a way to increase low level spread in the future, not a surprising result since it is known that land-surface (including soil moisture) perturbations are needed for adequate boundary-layer forecast spread. The forecasted upper level U spread is larger than the initial field but the middle and low level forecast spread is smaller than initial ones except for the 3-h forecast.

The ensemble spread at the surface for moisture field at 0-h (12Z), 3-h (15Z), 6-h (18Z), 9-h (21Z), and 12-h (00Z) forecast lead times (valid times) are shown in Figure 2. We can see the clear patterns in the moisture spread field in Oklahoma and Texas and Florida, which may be related to the active convection later in those areas during this period.

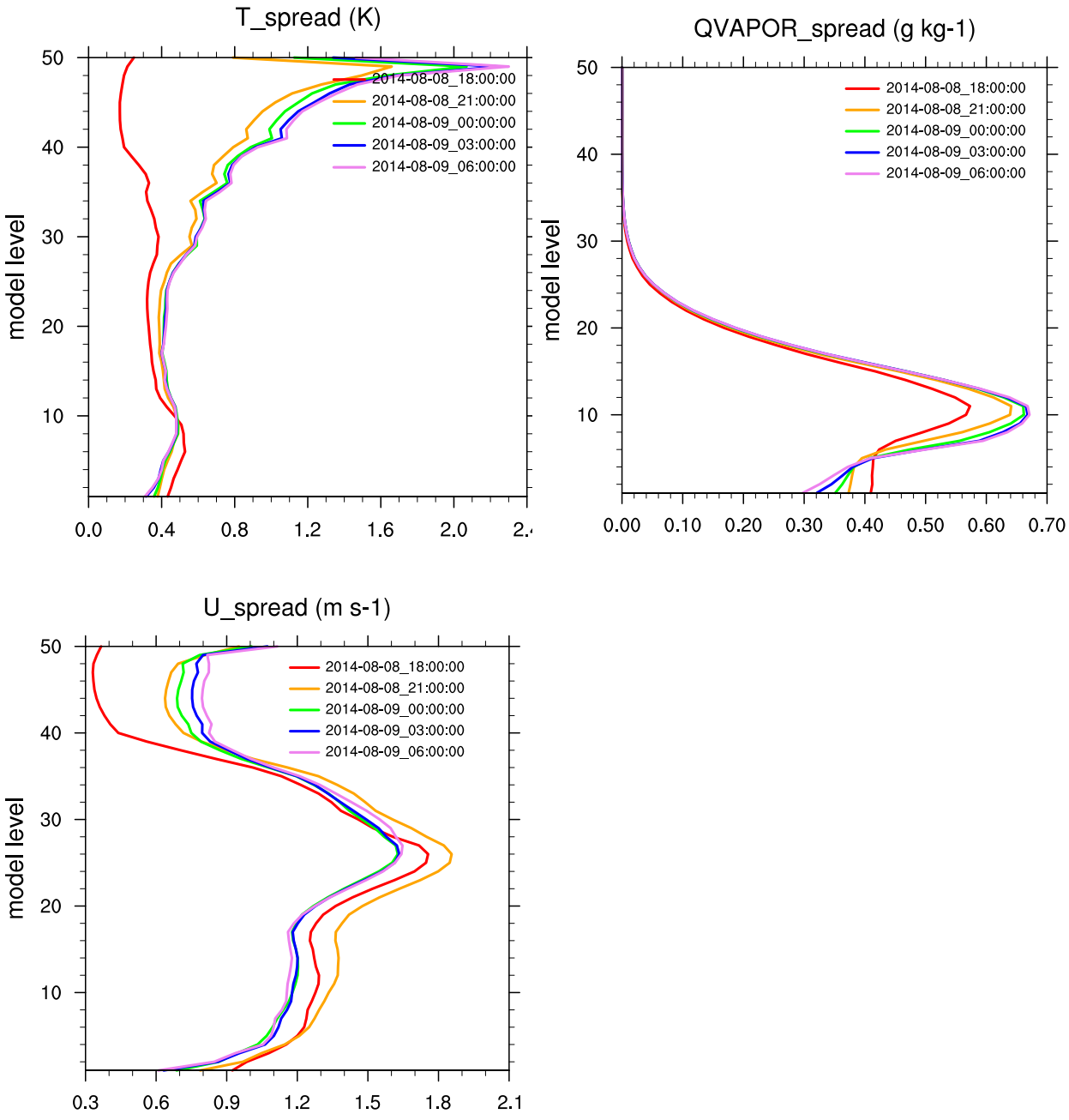

Figure 1. Vertical profile of horizontally-averaged ensemble spread for T, Q, and U, at the 0-h (12Z), 3-h (15Z), 6-h (18Z), 9-h (21Z), and 12-h (00Z) forecast lead times (valid times).

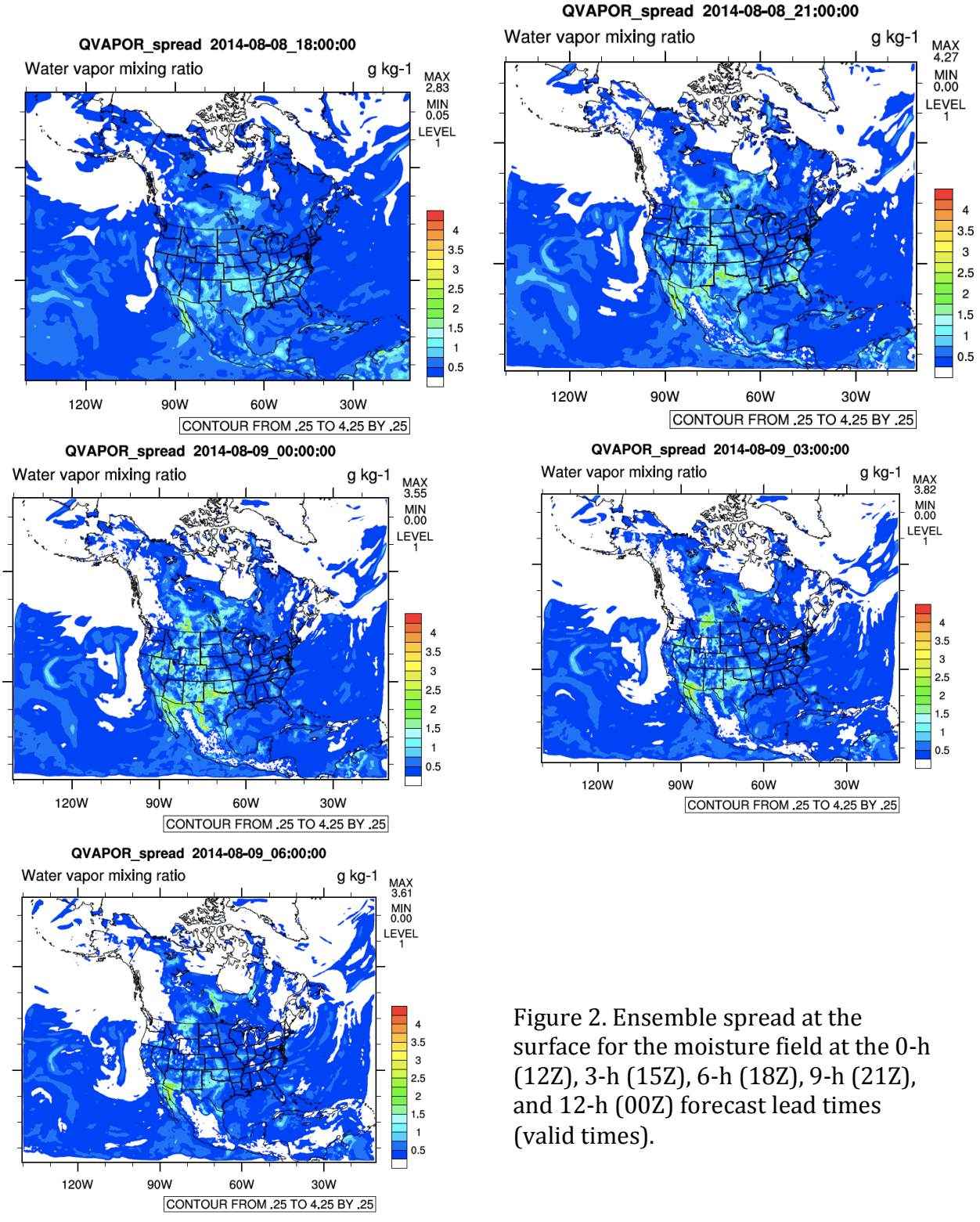

Figure 2. Ensemble spread at the surface for the moisture field at the 0-h (12Z), 3-h (15Z), 6-h (18Z), 9-h (21Z), and 12-h (00Z) forecast lead times (valid times).

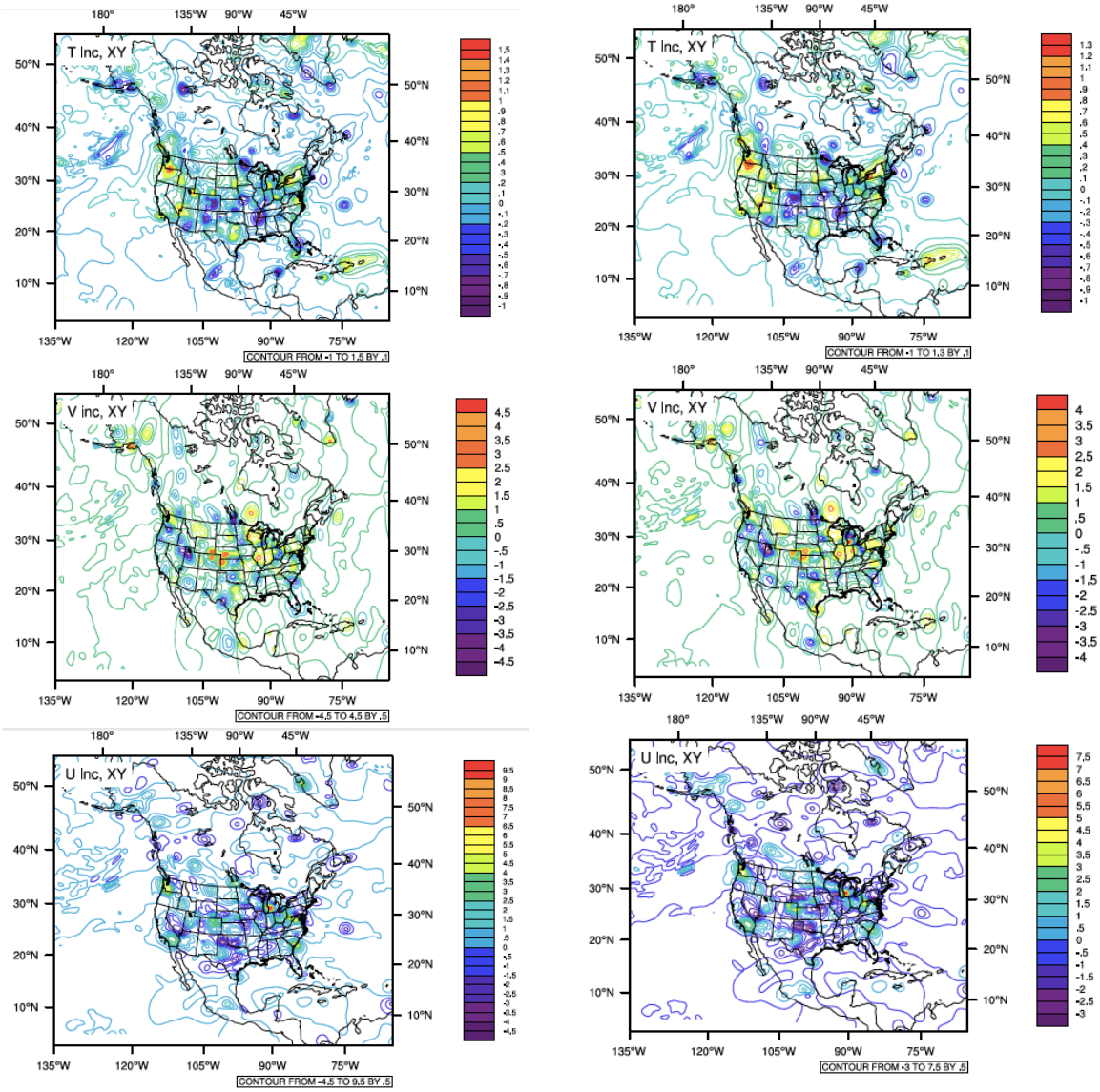

Figure 3, GSI hybrid analysis increments of 16th model level at March 25, 2105. Right column is with 6-h GFS ensemble from 06Z, March 25, 2105 and left column is with RAP ensemble initial fields at 12z, March 25, 2105. The 1st row: temperature, 2nd: V; 3rd: U.

3. Test GSI with RAP ensembles

A further study was done by running the RAP GSI hybrid case using both the GFS ensemble and RAP ensemble. The two GSI-hybrid cases at 12Z, March 25, 2105 were conducted:

1) RAP GSI hybrid analysis with the GFS 6-h forecast from 06Z, March 25, 2105
2) RAP GSI hybrid analysis with the RAP ensemble initial fields at 12Z, March 25, 2105, which is downscaling from the GFS 6-h forecast from 06Z, March 25, 2105

The GSI-hybrid successfully ran through with the RAP ensembles at the same resolution ensemble grid with analysis grid. To make a fair comparison, the GSI-hybrid with GFS ensemble also conducted over the ensemble grid with the same resolution as analysis grid. Those GSI runs need about 400 cores because of the high-resolution ensemble grid and about 20 minutes to finish. Figure 3 shows the T, U, V, and Q analysis increment at 16^{th} model level from both runs. From those analysis increments, we can see they have similar patterns and values. This verified the downscaling GFS ensemble to generate RAP ensemble has been done correctly.

3. Testing for RAP retrospective test period

Previously used 2014 RAP retrospective test periods are being used for testing the impact of the RAP ensemble. We have finished a control run with low resolution GFS ensembles and with RAP operational configuration. We are now running a retro with high resolution GFS ensemble forecast to evaluate the impact of GFS ensemble upgrade in January, 2015. Next two retro cases will be:

1) run RAP GSI hybrid with high-resolution GFS ensemble and high resolution ensemble grid (1x grid)
2) run RAP GSI hybrid with RAP hourly ensemble forecast